Extended Emission Around Nearby Seyfert 1 Galaxies

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DATA REDUCTION & PRESENTATION

CXO DATA: To enable direct comparison, only 0th-order HETGS data in the 0.3-1keV band are shown. (The hard-band images generally only reveal the nucleus & point sources.) All datasets were processed using CIAO(v2.3), CALDB(v2.18) & HEAsoft (v5.2). Multiple OBSIDs were combined after masking the readout-stripe & dispersed spectra from both the data & exposure map.

All CXO images have been adaptively smoothed (using 5 counts), and use ***the same colortable*** which is scaled to cover the same dynamic range in units of photons/s/kpc^2 appropriate for the source.

HST DATA: Both [OIII] and V-band images were extracted from the archive, but in several cases are yet to be cleaned.

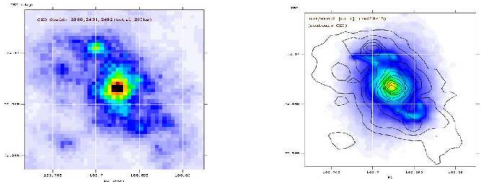
All images are ***4kpc*** on a side unless otherwise stated.

OVERVIEW

We are conducting a search for & study of diffuse X-ray emission surrounding nearby Seyfert nuclei using CXO. If present, the X-ray morphology will be compared to other orientation indicators such as those obtained in the radio, narrow optical/UV emission lines etc.

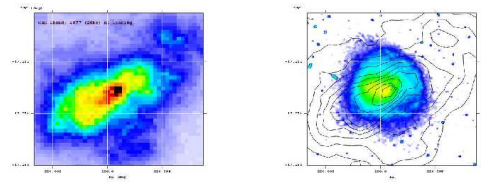
Preliminary results from a subset of our sample are presented here. In this admittedly biased and hetergeneous subset, extended X-ray emission is seen to be common (where not swamped by the nucleus) with a variety of characteristics.

NGC 3516— Seyfert 1 galaxy (37Mpc, 179 pc/arcsec)



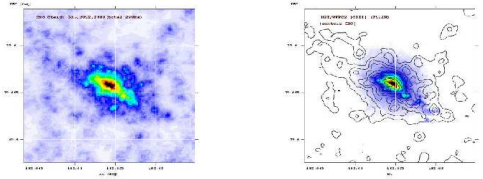
Extended X-ray emission seen out to at least 1.5 kpc on either side of the nucleus (+ a point source to the NE). The NE-SW and 'Z-shaped' morphology is similar to that seen in [OIII]. More data is included here, but the overall results of George et al (2002) are confirmed.
Extended X-ray emission around NGC 3516 was suspected in a ROSAT/HRI observation (Morse et al.1995). A detailed study of the HST/WFPC2 observations is presented in Ferruit et al (1998).

NGC 5728— Seyfert 2 galaxy (40Mpc, 192 pc/arcsec)



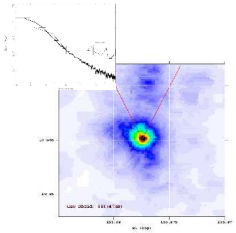
Approximately elliptical (2kpc x 1kpc) extended X-ray emission seen with the major axis to the SE-NW (~2kpc). The relationship between the X-ray and [OIII] morphologies is unclear. A detailed study of the HST/WFPC2 observations is presented in Wilson et al (1993).

NGC 4151— Seyfert 1.5 galaxy (14 Mpc, 68pc/arcsec)



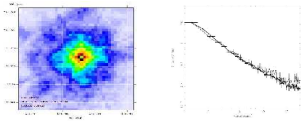
Extended X-ray emission seen out toat least 1 kpc on either side of the nucleus. The morphology is more linear than NGC 3516 and similar to that seen in [OIII].More data is included here, but the overall results of Ogle et al (2000) are confirmed. A detailed discussion of the extended NLR in this galaxy by many authors (eg. Perez-Fournon & Wilson 1990).

NGC 3227—
Seyfert 1 galaxy
(30Mpc,145pc/arcsec)



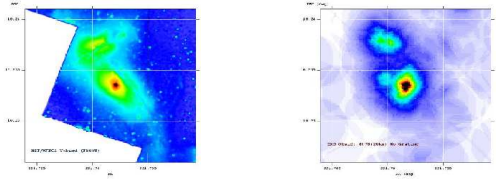
Only extended X-ray emission seen is at the very low level (~3e-4 photons per pixel per second), most noteably extending out to 2kpc to the N. The inset shows the radial PSF of this region compared to that expected from to the nucleus alone. Extended [OIII] emission yet to be detected in this heavily-reddened source. Several detailed studies of the extended NLR in this galaxy has been presented
(eg. Gonzalez Delgado & Perez 1997).

NGC3783—
Seyfert 1 galaxy
39.3 Mpc,
190 pc/arcsec



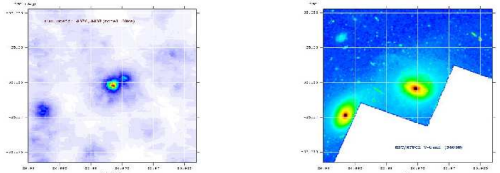
In this and several other sources any extended emission on levels & scales similar to (say) NGC 4151 will be swamped by the very bright nucleus.

NGC 7212—Seyfert 2 galaxy (114Mpc, 551 pc/arcsec)



(30kpc images)NGC 7212 is one of 3 interacting galaxies. Extended X-ray emission is seen out to 15kpc to the NNE. There is a region of enhanced emission at the site of the interaction, and a smaller region ~3kpc to the E of the nucleus. Detailed discussion of the optical morphology of these galaxies is presented in Durret (1994) and Kotilainen (1998).

NGC 526A—Seyfert 1 galaxy (77.98 Mpc, 377 pc/arcsec)



(30kpc images)The extended X-ray emission seen 5kpc to the NW of the nucleus. Weak X-ray emission is also seen from the other galaxy in this pair (NGC526B). Detailed discussion of the HST observations has been presented by Mulchaey et al (1996) and Malkan et al (1998).

FUTURE WORK

Our initial research look promising, so we intend to develop this study, including:
considering a much larger set of objects (as unbiased as possible)
performing a more-detailed comparison between the X-ray morphology and that seen in other wavebands
Investigating the spectral characteristic of the X-ray emission
developing physical models for the circumnuclear ionized gas in Seyferts
comparing our results to unified schemes

References:
Durret, 1994, A&AS, 105, 57
Ferruit et al, 1998 ApJ, 509, 646
George, et al, 2002, ApJ, 571,265;
Gonzalez Delgado & Perez, 1997, MNRAS, 284, 931
Kotilainen, 1998, A&AS, 132, 197
Malkan et al, 1998, ApJS, 117, 25
Morse et al, 1995, ApJ, 439, 121
Mulchaey et al, 1996 ApJS, 102, 309
Ogle, et al, 2000, ApJ, 545,81
Perez-Fournon & Wilson, 1990, ApJ, 356, 456
Wilson et al, 1993, ApJ, 419, L61